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XXIX. *An Account of the Lymphatic System in Fish. By the same.*

Read Nov. 16, 1769. **I**N the foregoing paper on the lymphatic system in a turtle, I have made no mention of the manner of discovering, and demonstrating those vessels; the reason was, there is no difficulty in either the one or the other; for, in that animal the mesentery being very thin and transparent, and the lacteals pretty large, they are more readily discovered than in any other animal; thence it happened that I saw those vessels in a turtle long before I discovered them in birds and fish, and that too by chance, and when I was not intent upon this inquiry. And since I drew up the preceding account, I have found that Mr. John Hunter, in a description of the structure of a crocodile, had mentioned, by the way, that it had lacteals. Professor Monro, of Edinburgh, as I have been informed, likewise saw the lacteals in a turtle about four years ago. As it is natural for men, engaged in the same inquiries, to be desirous of ascertaining their priority in the discoveries, even when there is little merit in the making them, I therefore take this opportunity of doing justice to those gentlemen, and at the same time

time of mentioning that I first saw those vessels, as near as I can recollect, in September or October 1763, which, as far as I know, was before they had been seen by either of them.

But although it was an easy matter to see those vessels in the turtle, yet it was far from being so in birds and fish; as the gentlemen of the Society will readily believe, from their having been so often sought for in vain by so many eminent anatomists, particularly of this age. I may add, that the discovery in birds did not give me so much trouble as that in fish, though now, since I have seen them in the latter, I can more readily find them there than in birds or quadrupeds. After seeing them in birds, and in one of the *amphibia*, I was very desirous of determining whether fish were, or were not provided with those vessels. This I endeavoured to do in the same way that I had found them in birds, that is, by tying up the mesenteries of live-fish; and for this purpose I went frequently to the markets, and examined several small ones. I likewise dissected some larger, when dead, but in vain. I next went to Brighthelmstone, where I found kingston, or monk-fish, a species of skate. These being very large, and having a lean mesentery, seemed well fitted to my purpose. I opened two of them alive, tied up their mesenteric vessels, and put them again into the salt water; and though one of them lived an hour, I could not observe any lacteals either upon its intestine or its mesentery. After this, I repeatedly examined the intestines and mesenteries of common skate and cod, and at last was so fortunate as to discover the lacteals, and get a pipe into one of those vessels on the mesenteries of each of these

these fish; and, by injecting by this pipe, I found where the larger vessels lay; after which there was but little difficulty in tracing the whole system. I have now seen those vessels in a variety of fish, and shall give a description of them from a haddock. I shall proceed exactly in the order which I have found most convenient for tracing out the whole system for demonstration, beginning with one of its branches, which, as lying nearest the surface, must, of course, be divided before the other parts can be exposed to view. The account being taken from the fish as it lay on its back, those parts are called superior which are nearest the head; those inferior, which are towards the tail, those posterior which are towards the back, and those anterior which are towards the belly.

On the belly of the fish, exactly in the middle line, is a lymphatic, which runs from the *anus* upwards; this lymphatic belongs not only to the *parietes* of the belly, but to the fin below the *anus*. It runs up towards the head, passes between the two jugular fins, and, having got above them, it receives their lymphatics. It then goes under the *symphysis* of the two bones which form the *thorax*, where it opens into a net-work of very large lymphatics, which lies close to the *pericardium*, and almost intirely surrounds the heart. This net-work, besides that part of it behind the heart, has a large lymphatic on each side, which runs upon the bone of the *thorax* backwards, and when it has got as far as the middle of that bone, it sends off a large branch from its inside to join the thoracic duct. After detaching this branch, it is joined by the lymphatics of the pectoral fins, and

soon after, by a lymphatic which runs upon the side of the fish. This last-mentioned vessel consists of a trunk running on the side just opposite to the ribs, and from this trunk proceed branches on each side immediately under the skin; so that it has a beautiful penniform appearance. Besides these branches, there is another set deeper seated, which accompany the ribs. After the large lymphatic has been joined by the above-mentioned vessels, it receives the lymphatics from the posterior extremities of the gills, and having now got as far back as the orbit, it next receives lymphatic vessels from that cavity; but these vessels do not belong merely to the orbit; for one of them comes from the nose, and another from the upper part of the mouth. A little below the orbit, another net-work appears, consisting, in part, of the vessels above described, and of the thoracic duct. This net-work is very complex; some of its vessels lie on each side of the muscles belonging to the gills, and from its internal part a vessel goes into the jugular vein, by which vessel the whole system is terminated. The large lymphatic above mentioned, which lies upon the bone of the *thorax*, has likewise a process running towards the upper part of the kidney, and receives some of the lymphatics of that organ.

The lacteals run on each side of the mesenteric arteries, anastomosing frequently across those vessels. The *receptaculum*, into which they enter, is very large in proportion to them, and consists, at its lower part, of two branches, of which one lies between the *duodenum* and stomach, and runs a little way upon the *pancreas*, receiving the lymphatics of the liver, *pancreas*, those of the lower part of the stomach, and the

the lacteals from the greatest part of the small intestines. The other branch of the *receptaculum* receives the lymphatics from the *rectum*, and the lacteals from the greatest part of the small intestines. The *receptaculum*, formed by these two branches, lies on the right side of the upper part of the stomach, (or the lower part of the *œsophagus*) and is joined by some lymphatics from that part; and also by some small vessels from the sound, and from the gall bladder, which, in this fish, adheres to the *receptaculum*. The thoracic duct takes its rise from the *receptaculum*, and lies on the right side of the *œsophagus*, receiving lymphatics from that part; and running up a little way (viz. about half an inch in this fish) it divides into two branches or ducts, one of which passes under the *œsophagus* to the left side, and the other goes straight up, on the right side, runs past the upper part of the kidney, from which it receives some small branches, and soon after it is joined by a branch from the large lymphatic that lies above the bone of the *thorax*, as formerly mentioned. It likewise, near this part, sends a branch to join the duct of the opposite side, and then, a little higher, is joined by those large lymphatics which make a net-work behind the heart, as formerly described. These last mentioned vessels receive the lymphatics from the anterior, or superior part of the gills, and from the *fauces*. The thoracic duct, after being joined by these vessels, communicates with that net-work near the orbit; where its lymph is mixed with that of the lymphatics from the posterior part of the gills, from the superior fins, belly, &c. and then from this net-work a vessel goes into the jugular vein, just below the orbit. This last vessel,

vessel, which I called the termination of the whole system, is very small, in proportion to the net-work from which it rises; and indeed the lymphatics, at this part, are so large as to exceed by far the size of the sanguiferous vessels.

The thoracic duct of the left side, having passed under the *œsophagus* from the right, runs on the inside of the *vena cava* of the left side, receives a branch from its fellow of the opposite side, and joins the large lymphatics which lie on the left of the *pericardium*, and a part of those which lie behind the heart, and afterwards makes, together with the lymphatics from the gills, upper fins, and side of the fish, a net-work, from which a vessel passes into the jugular vein of this side. In a word, the lymphatics of the left side agree exactly with those of the right, as above described.

Besides these vessels, there is yet another part of the system which is deeper seated, lying between the roots of the spinal processes of the back-bone: this part consists of a large trunk, that begins from the lower part of the fish near the tail, and, as it ascends, receives branches from the dorsal fins, and from the adjacent parts of the body. It goes up near to the head, and sends a branch to each thoracic duct, near the part where they come off from their common trunk.

This description, though taken from a haddock, agrees, I believe, pretty exactly with the distribution of those vessels in the cod, whiting, and perhaps all other fish of the same shape.

To this general description I shall add what I have observed of the more remarkable peculiarities of this system in fish.

In the first place, those vessels are remarkable in not having any lymphatic glands, that I can discover, in any part of their course. In this they agree with the turtle, but differ from birds, which have lymphatic glands on the vessels of their necks.

Secondly, these vessels in fish have no valves, so that it is an easy matter to fill them contrary to the course of the lymph. When I first observed this circumstance, I imagined that, by injecting minutely those vessels, I might discover their very beginnings, and that I might also be enabled to determine, whether such parts as the brain, eye, &c. whose lymphatics have not been yet seen in any animal, have, or have not, such vessels. At present I am not able to determine this matter, but I intend to prosecute the subject.

Thirdly, the lacteals in the cod (and I presume in most other fish) are remarkable for having a beautiful net-work of vessels between the muscular and vilous coat of the intestines (*c*). This net-work may be filled from the lacteals on the mesentery with the least force imaginable. If mercury be injected into this net-work at one part, it spreads over the intestine; the communications in the net-work being very numerous: if the intestine be inverted, and the mercury squeezed, it is easily driven into the small vessels of the *villi* of the internal coat. From these vessels the mercury can be squeezed into the cavity of the intestine; but not so easily as to make it clear whether they have, or have not, a valve at their beginning. In these circumstances there is a strong

(*c*) I have seen this net-work in the turbot, plaice, and cod.

analogy between fish and the turtle ; but in fish it is more evident that there can be no deception as to the net-work between the muscular and internal coats ; for in them it is made up of cylindrical vessels, and is not cellular, as in the turtle, and therefore not in the least like an extravasation : and in fish the vessels on the internal coat are larger than in turtles.

Fourthly, this system agrees with that of the turtle, in having a very large *receptaculum*, and in having the net-work of large vessels near its termination in the sanguiferous system ; and likewise in having the vessel, which goes from the net-work into the vein, small in proportion to the size of that net-work : so that the lymph must be lodged some time in those parts before it is poured into the mass of blood. In birds I also observed something like this, their lymphatic system being enlarged or varicose at different parts ; but these enlargements are small in proportion to those above mentioned in fish and turtle.

As to the manner of discovering those vessels in a fish, one might naturally suppose, that when we know where the *receptaculum*, or any of the larger parts of this system lie, it could not be difficult to find them ; but the coats of these vessels are so thin and transparent, that it is by no means easy. But the readiest way of finding the whole system is, to look for one of the vessels which lie close to the skin ; as, for instance, that which runs up exactly on the middle of the belly of the haddock, cod, and other fish of the same shape. This vessel is easily seen as it grows pretty large where it passes between the two jugular fins ; and if a pipe be introduced, the whole system may be filled by means thereof.

It is partly owing to the ease with which those vessels may be seen, after discovering where their larger branches lie, that I have not added a figure of this system in a fish. Indeed it would be almost impossible to express all its parts in one figure, from the numerous and intricate communications of those vessels near their termination in the common veins. But I have laid before the R. Society a haddock with its lymphatics and its blood-vessels filled with coloured injections, to be compared with the description. And those that are desirous of prosecuting this subject further will, I flatter myself, find it an easy matter to fill the whole system, by attending to what I have said above.

I shall beg leave to add one observation more ; and that is with respect to the distribution of the lacteals on the *villi* (as they are called) of the intestines. From a variety of experiments, which I have made, I am persuaded, that in animals, in general, each of the *villi* is composed of a net-work of lacteal vessels, as well as of a net-work of arteries and veins. The very ingenious Dr. Lieberkühn has endeavoured to shew, that in the human subject each lacteal forms an *ampullula* or oviform vesicle, which is filled with a spongy substance. But from having injected those vessels, with mercury, in fish, turtle, and birds, I can clearly demonstrate that each of the *villi* of these animals has a net-work of lacteals, and not an *ampullula* or oviform bag. And from comparing these observations with Dr. Lieberkühn's experiments, I am inclined to believe the structure is similar in the human subject. But as proposing my arguments at present would not be altogether agreeable to the design
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of this paper, I shall refer that subject to some future occasion. In the mean time, as I flatter myself that it may not be unacceptable to the learned Society, I have ready to lay before them a collection of preparations, which demonstrate not only these facts relating to the *villi*, but others that are mentioned in this and the preceding paper. Of these preparations here follows the list.

- N^o 1. A turtle, with its lymphatic and its sanguiferous systems filled.
2. A haddock, with its lymphatic and sanguiferous systems filled with injections of different colours.
3. The lymphatics on the stomach of a cod, filled with mercury; the arteries with a red, and the veins with a green injection.
4. The lymphatics on the stomach of a turbot.
5. The lacteals on the mesentery and small intestine of a cod. In this preparation the arteries are filled with a red, and the veins with a yellow injection, and the lacteals with mercury; and, the preparation being afterwards dried, the lacteals are seen to form a curious net-work of vessels between the muscular and the villous coat.
6. The same in a bottle.
7. The lacteals on the gut of a skate. In this preparation the lacteals are filled with mercury, the artery with a red, and the vein with a green wax.
8. The lacteals on the mesentery and intestines of a turbot. In this preparation the vascular
net-work

net-work between the muscular and villous coat is likewise very distinctly seen.

9. The mesentery and a piece of the intestine of a turtle ; where the lacteals are seen filled with mercury, not only on the mesentery, but on the whole external surface of the gut, forming a beautiful net-work.
10. The same. In this the arteries are filled with a red, the veins with a blue injection, and the lacteals with mercury, and the preparation being afterwards dried, the lacteals are seen not only on the mesentery and the external surface of the intestine, but the cellular net-work between the muscular and the villous coat is likewise distinctly seen.
11. The same, where the cellular net-work is filled all around the intestine.
12. Three preparations of the intestines of a turbot, in which the lacteals are seen to make a net-work on each of the *villi*.
13. Three more preparations from the same fish ; where the lacteals are filled with mercury, and the arteries and veins with a coloured injection ; each forming a net-work on the *villi*.
14. Three preparations of the gut of a turtle, where the lacteals on the *villi* of the internal coat are filled with mercury, and form a net-work.
15. A piece of the gut of a goose, in which the lacteals of the *villi* are filled with mercury ; the arteries with a red, and the veins with a yellow injection. In this preparation both
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the lacteals, arteries and veins are seen to make a net-work on many of the *villi*.

16. A piece of the stomach of a cod, in which the lymphatics are filled with mercury, and very minutely. They are seen to go through the external coats of the stomach, dividing into smaller and smaller branches, without any appearance of a net-work between the muscular and the villous coat ; and as a considerable force was used in the injecting them, I am inclined to believe that the stomach in fish has not the net-work of vessels between the muscular and the villous coat, as the intestines have (*d*).

(*d*) These preparations were laid before the Society on the same evening this paper was read.